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ANIMALS THAT ARE INDICATORS OF MARINE POLLUTION

When marine communities are affected by pollution, species richness often decreases while the abundances of a few tolerant species increase. The resultant changes in invertebrate community structure, diversity, and abundance are the responses of these benthic animals to the physical and chemical changes in their environment. The identification of the thousands of animals required to show these distributional patterns--and hence the extent of the pollution effects--is costly and time consuming; to over-come this problem, the concept of "indicator species" was tested. Indicator species, for the purpose of this paper, are those whose changes in abundance reflect overall changes in the normal patterns of invertebrate communities. By monitoring the changes in a few selected indicator species, the expense of biological monitoring can be drastically decreased.

The objectives of this study were to select indicator species for five southern California areas that receive major discharges of municipal wastewaters. The result was the identification of four groups of indicator species, containing a total of nine southern California subtidal benthic invertebrates, which did in fact—by their abundances—define the areas of impact around each of the five discharge locations.

Past studies of pollution indicator species in southern California have been confined to the analysis of a particular fraction of benthic samples (e.g., polychaetes), and many of these studies have been confined to bays or harbors (for example, Reish 1955, 1959; Crippen and Reish 1969). In our study region, the southern California coastal shelf, there has been little work done on indicator species. Previously, the Project reported that *Parvilucina tenuisculpta* (a small clam) and the brittle star, *Amphiodia urtica*, were useful indicator species at several outfall sites (Coastal Water Research Project 1973). In recent community studies (Greene 1976), cluster analysis was used to group outfall stations with similar fauna; the resultant groups of stations were characterized by some of the same species selected as indicators in this study.

The extensive collection of monitoring data available for deepwater waste discharge locations was the basis for this study. We analyzed recent grab sampler data from each of the five major discharge locations in southern

California.* However, since much of this data had been collected using a variety of different samplers and techniques and were not directly comparable, we applied correction factors (ranging from 0 to 45 percent) derived in previous studies (Word 1975, 1976; Word et al. 1976) to the numerical information prior to beginning our analysis. The species identifications in most of the data used in this study were standardized through the Taxonomic Standardization Program (described elsewhere in this report), thereby allowing the use of these data as though they were identified by a single source.

A total of 50 benthic samples taken at a depth of 60 meters at 20 different stations were examined for the following biological characteristics:

- The number of species.
- The number of individuals.
- Gleason's Diversity Index.
- The number of species accounting for 70 percent of the total fauna.
- The relative percentage of animals belonging to each of the major taxonomic groups.
- The abundances of a maximum of twenty species from each sample.

On the basis of these characteristics, samples were designated as belonging to one of four categories, A through D. Indicator species—species that seemed to characterize each group of samples--were then selected, and the abundance of each species in each group was plotted (Figure 1). To determine the distance of impact around each outfall, data from 120 additional stations were examined, and each of these stations was assigned to a category, according to the abundance of the indicator organisms present.

In general, decreasing numbers of species, increasing numbers of individuals, and decreasing diversity values are common responses observed near outfall discharge sites. The data we examined support this well-documented observation: With increasing proximity to the outfalls, the average number of species present decreased from about 60 to 20/0.1 sq meter, the average number of individuals increased from 1,500 to 9,000/sq meter, and diversity—as calculated by two methods—decreased (Figure 2). The most affected stations, those in Category A, were dominated by polychaetes, which accounted for over 90 percent of the individuals present; pelecypods accounted for only about 5 percent of the organisms collected at these stations. Indicator species in this category were the polychaetes, *Shistomeringos longicornis, Capitella. capitata, and Armandia bioculata* and the clam, Sotemya pancanensis; although these species do occur individually in other areas, they have not been reported as occurring together except in regions of heavy outfall contamination. The sediments from these heavily contaminated areas also contained large quantities of finely shredded plant

*Ventura Regional County Sanitation District, City of Los Angeles (Hyperion), Los Angeles County Sanitation Districts, Orange County Sanitation Districts, and the City of San Diego.

material and, when collected, were marked by sulfide odor.

Stations in Category B were dominated by the pelecypod, *Parvilucina tenusculpta* (approximately 3,500 individuals/ sq meter or more), which accounted for over 60 percent of the individuals in the samples.

The transitional stations, those in Categories C_1, C_2, and C_3, were more difficult to characterize using indicator species. Polychaetes accounted for 15 to 40 percent of the fauna in samples in these categories, and pelecypods accounted for 25 to 60 percent. While *P. tenuisculpta* abundance showed a continuous decrease from about 2,000/sq meter in Category C_1 to less than 500/sq meter in Category C_3, this species still accounted for 20 to 30 percent of the total fauna taken at Category C_3 stations. The ophiuroid, *Amphiodia urtica*, showed a gradual increase in abundance from 0 to about 50 individuals/sq meter. Indicator species for these transitional regions were the polychaetes, *Mediomastus californiensis*, *Tharyx spp*., and ostracods of the genus *Euphilomedes*. These species are also abundantly found in areas other than outfall sites, but enhanced abundances of one or all of them, combined with the presence of *Parvilucina tenuisculpta* in numbers accounting for 20 to 30 percent of the total fauna, appeared to be indicative of the transitional regions.

Sediments from background or "control" locations (Category D) on the southern California shelf at depths of 60 meters typically contained the ophiuroid, *Amphiodia urtica* and the clam, Parvitucina tenuisculpta, in quantities greater than 100 individuals/sq meter; these species together accounted for about 10 to 20 percent of the total number of individuals in the samples from stations now considered to be control areas.

Selection of indicator species allowed us to make direct comparisons of the effects created by waste discharge at each of the five areas in southern California with a new set of data. The most affected zones, those in Category A, were found downcurrent at a maximum distance of 4.6 km from the discharge location at Palos Verdes; 1.9 km downcanyon from the Hyperion 7-mile sludge line in Santa Monica Bay, and at a single station located at the end of Orange County's diffuser. No stations off Point Loma were classified as belonging to Category A.

The areas classified as Category B were found on both sides of some of the discharges. On the northwest side of the pipe at Palos Verdes, stations of this category extended from 5.6 to 11 km from the outfall system; on the southeast side, stations of this type extended to the end of the sampling grid, 5.6 km from the outfalls. Category B stations extended 2.8 km downcanyon in Santa Monica Bay and 0.93 km inshore of the discharge pipe on the shelf. Only one Category B station was found near Orange County's outfall; this station was located 0.5 km from the end of the diffuser. No Category B stations were found off Point Loma.

Transitional conditions. Category C, were found at one Palos Verdes station located 16.7 km downcurrent (northwest) from the discharge. However, in Santa Monica Bay, stations of this type were found 2.8 to 6.5 km downcanyon of the outfall system. Off Orange County, we found transition stations 0.5 to

3.5 km downcurrent of the outfall and up to 3.0 km upcurrent. One station 0.75 km downcurrent of the Point Loma outfalls could be classified as Category C.

The remaining stations that we surveyed in the out-fall areas were classified as Category D, unaffected by the wastewater discharge. The proximity of these stations—thought to represent background or "control" conditions—to each outfall system varied; Category D stations were found less than 1.5 km from the Point Loma

outfall, but the sampling grid off Palos Verdes, which extends 16.7 km downcurrent of the outfall system, did not contain any Category D stations.

Data on one of the Category B indicator species, the clam, *Parvilucina tenuisculpta*, revealed another possible response to wastewater discharges. Specimens taken in areas most heavily influenced by discharges were larger than those taken at a control site, and the largest specimens found in the survey were collected at the station nearest the Palos Verdes outfall system (Figures 3 and 4) . *P. tenuisculpta* may be an important food resource for a variety of fish and invertebrates, and we feel it would be worthwhile to further investigate the increased abundance of this animal at some outfall stations and the increase in size of individuals in discharge areas.

Data from a recent study of stations at 60-meter depths all along the southern California coast (described elsewhere in this report) suggest that the Category D stations in the vicinity of some outfalls are affected by the discharge and are not suitable as control stations. In addition, as correction factors had to be applied to much of the data because of the different types of sampling gear and techniques used at each outfall location, we must consider these data to be preliminary until the 60-meter benthic survey, in which a single sampler and standardized techniques were used, has been completed.

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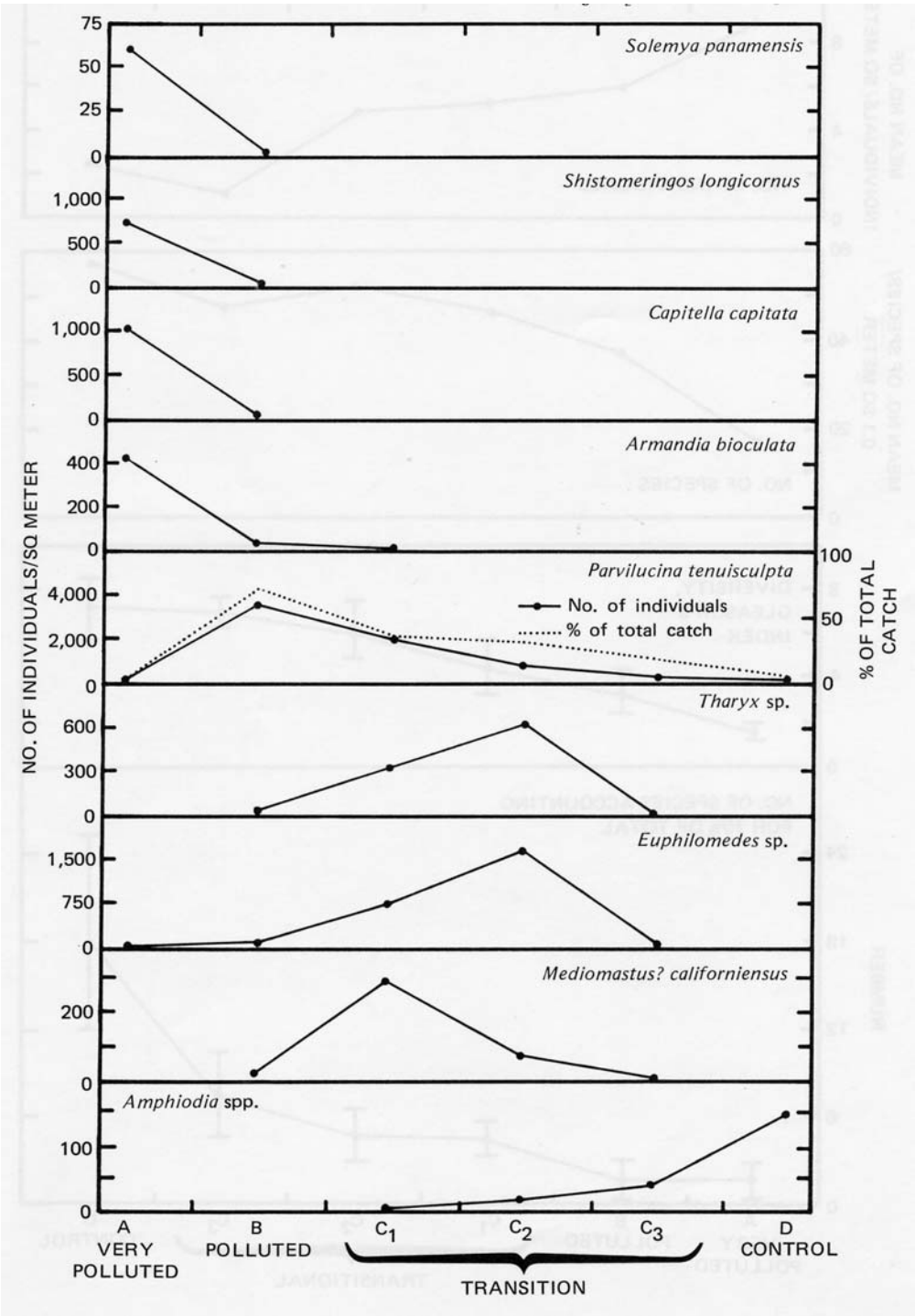

Figure 1. Mean abundance of "indicator species" at stations representing different categories of pollution.

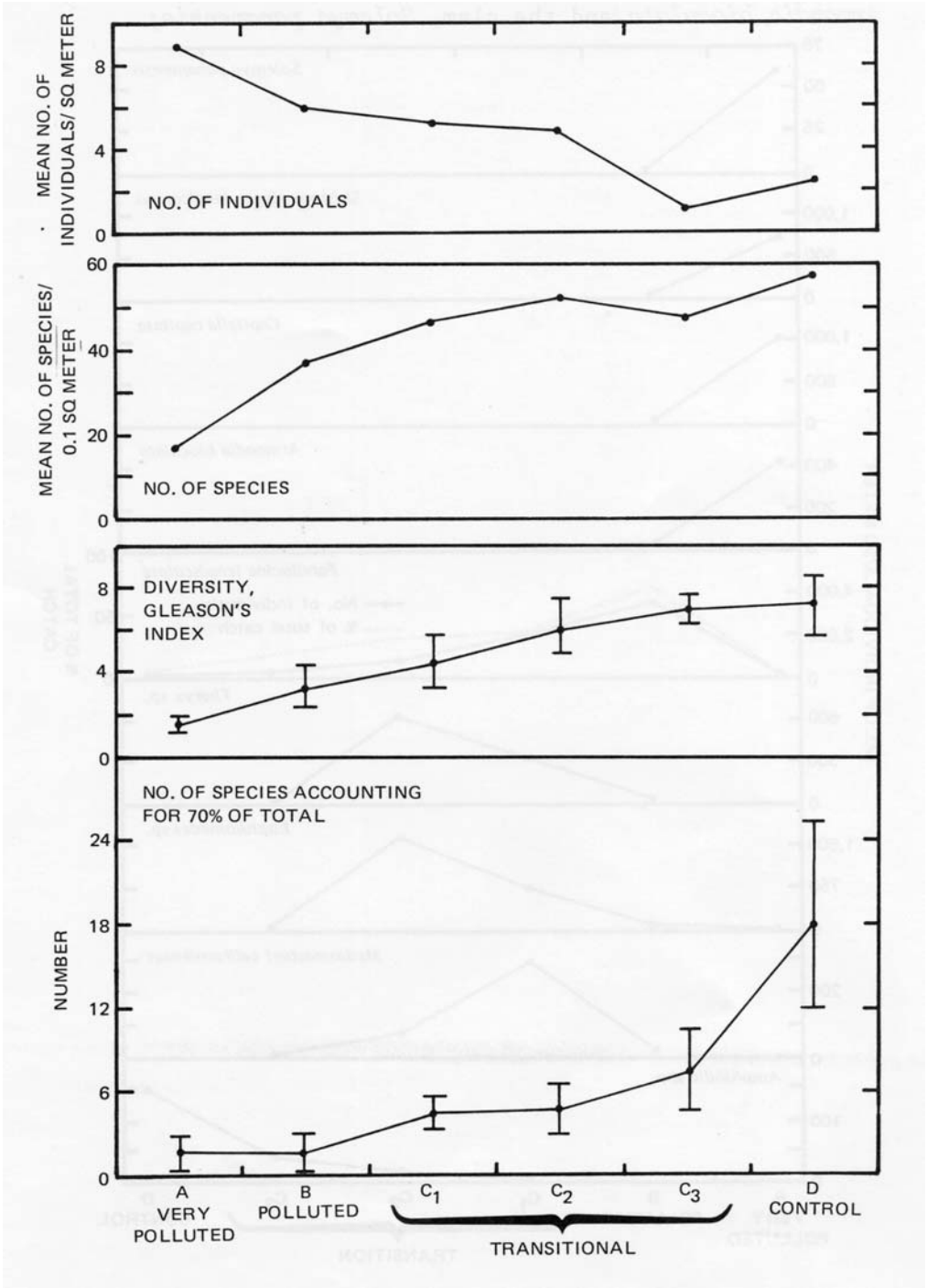

Figure 2. Biological characteristics associated with different categories of pollution.

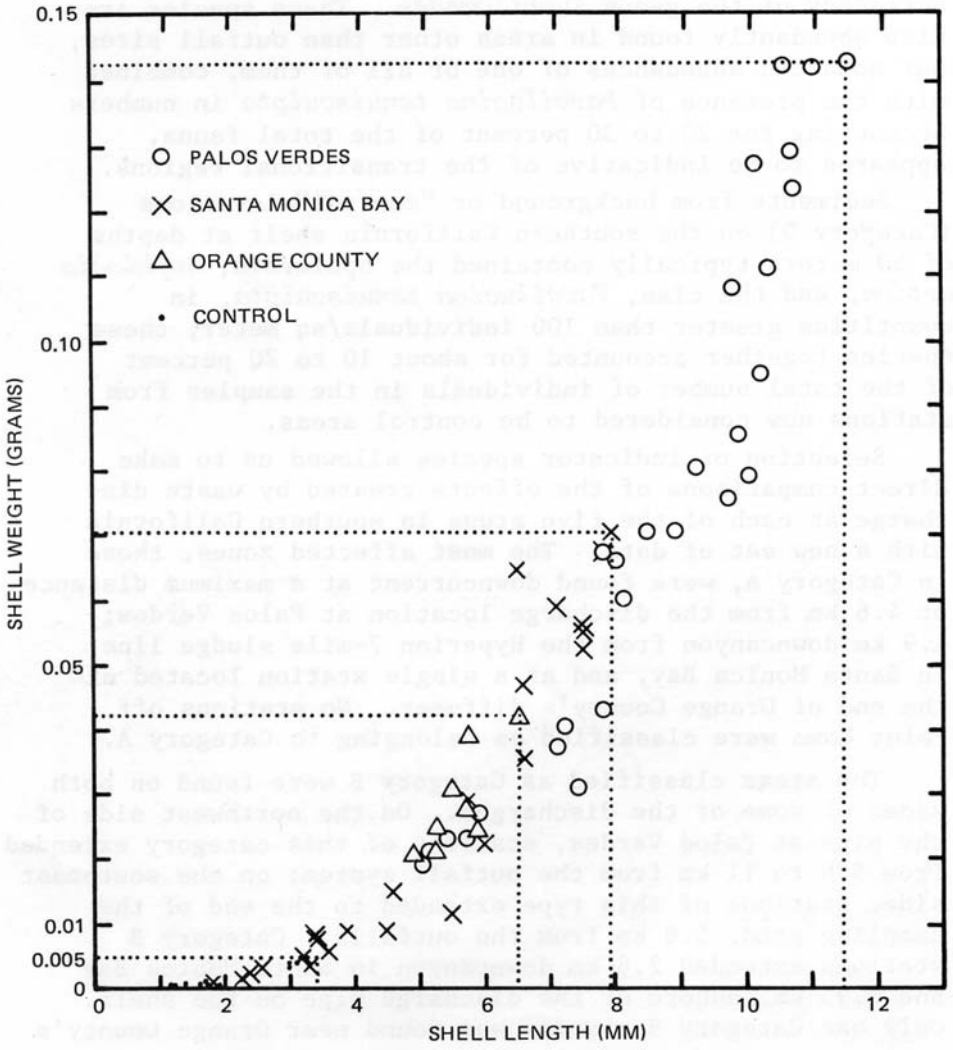

Figure 3. Relationship between shell length and shell weight in *Parvilucina tenuisculpta* collected in three areas affected by wastewater discharges and at a control site.

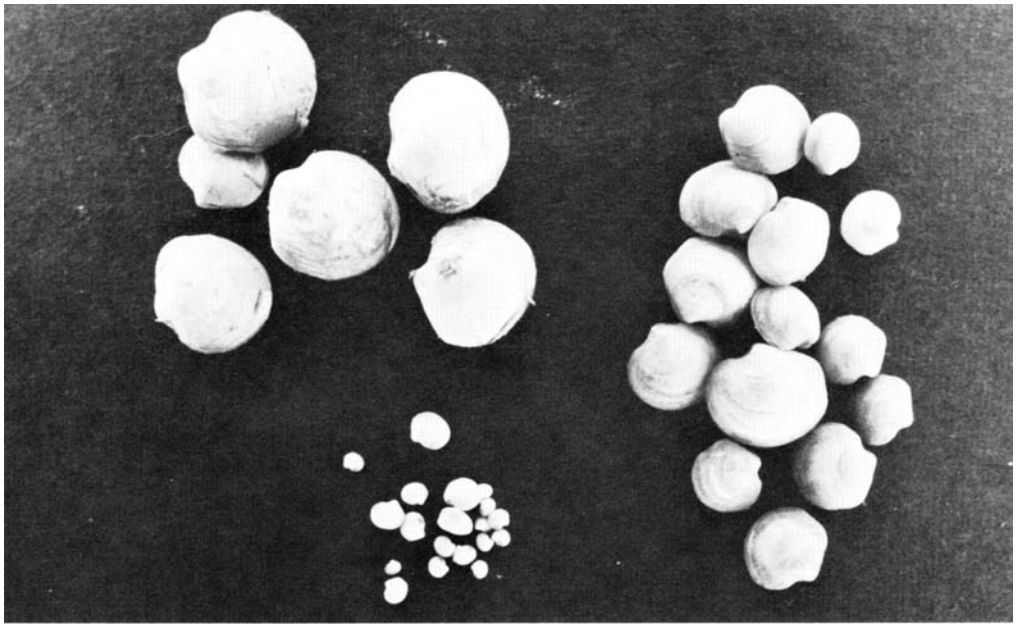

Figure 4. ***Parvilucina tenuisculpta*** **from three areas off southern California. The upper left group is from Palos Verdes, the upper right group is from Santa Monica Bay, and the lower group is from Trancas (north of Point Dume).**